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STEM and gender at university: focusing on Irish undergraduate female students' perceptions

Regina Kelly, Louise Lehane, Oliver McGarr & Sibel Erduran

Purpose

The purpose of this study was to identify whether or not females believe they associate with the culture of STEM by investigating the perceptions of female students currently enrolled in STEM courses.

Design

The paper presents data from a survey on female STEM students' 'Perspectives of Women in STEM', 'Parents' Science Qualification', 'Supports in their STEM Course' and their 'Science Identify' through a social capital lens. Both qualitative and quantitative methods were used to analyse the data.

Findings

The main findings was that female STEM undergraduates believe social bias, balancing work and family life and lack of role models are the main cause of less women in STEM professions and leadership positions. There were statistically significant differences between how male and female students identified with certain traits, with less females claiming to be intelligent and know about latest discoveries than males.

Implications

To eradicate stereotypical views of scientists it is recommended that Irish higher-education institutions introduce initiatives to increase the socialisation of STEM females within female networks and develop female students' self-awareness of their own capabilities. The expansion of STEM networks could act as a means to facilitate female students adopting positive science identities, increasing their science capital.

Originality Value

In Ireland, there is a paucity of literature relating to females' experience of STEM in higher education. This paper provides evidence that despite their engagement with STEM, female undergraduate students subscribe to the stereotypical image of the scientist. This study highlights the need to change the culture experienced by female STEM undergraduates in Ireland so as to improve the experiences and trajectories of women in higher education.

1. Introduction

Addressing the gender gap in Science, Technology, Engineering and Mathematics (STEM) is a major goal of many countries. In the past thirty years, many initiatives have been established to meet this challenge, but the gap still prevails. The Science in Australia Gender Equity report (2017) outlines that just 33% of STEM undergraduates conferring with a Bachelor's degree are female. Similarly, in the United States, The National Centre for Education Statistics (2016) report 35% of those who graduate with degrees are females, a ratio that has remained constant since 2008/2009. In Ireland, 48% of the students enrolled in tertiary level courses in the academic year of 2015/16 were female, similar to the United States and Australia, where approximately 36% of students enrolled in STEM courses were female. While appearing relatively high, this figure hides significant variations across the STEM spectrum with some areas very poorly represented. The Irish Higher Education Authority statistics of 2015/16 indicate that female students accounted for 68% (n = 68%) in Biology, 25% (n= 558) in Mathematics, 24% (n = 597) in Physics, 18% (n = 4018) in Information and Communication Technologies (ICTs), and 24% (n = 6633) in Engineering, Manufacturing and Construction. A similar picture emerges in Irish employment as less than 25% of the 117,800 workers in STEM occupations are female (The STEM Education Review Group, 2016). The UNESCO Institute for Statistics (2016) report that in relation to the number of female science researchers in Europe, Ireland is placed 32nd out of 41 countries with just 32.3%. All of these figures highlight the underrepresentation of females in science in Ireland and the need to focus on the Irish context regarding the gender gap in STEM.

Internationally, research has been conducted in relation to initiatives that identify variables at post-primary (or secondary) school level that are likely to lead a student to study science at third-level (Nicholls *et al.,* 2010; Archer *et al.,*2015) and that research has done a great deal in advancing our understanding of the challenges. This paper, however, departs from investigating the barriers female students face when aspiring to pursue STEM courses at primary and secondary levels. Instead, the study reported in the paper concerns the less-researched area of students who are already studying STEM programmes at university or the third-level. These students have already overcome the initial barriers associated with selecting a career in STEM which, within the Irish context, can be a challenge as there are some unique contextual factors of post-primary education that merit comment. For example, despite significant societal changes in recent decades and the decline of religious influence on the role of women in Ireland, subject choice at post-primary level continues to be influenced by historical stereotypes of gender. In schools where there is a broad subject offering, where females have the option to select male-dominated subjects such as Engineering, these subjects are commonly timetabled against female-dominated subjects such as Home Economics or Biology.

In addition, due to the historical legacy of church involvement in education in Ireland, there remains a significant number of single-sex schools in Ireland that offer subjects originally provided for either boys or girls. Added to these structural challenges is the need to select particular post-primary subjects to determine entry to third-level education. The vast majority of students entering undergraduate education in Ireland enter via completion of the state's Leaving Certificate (completed at the average age of 18yrs). This upper-secondary education qualification also acts as a matriculation mechanism for universities and students are required to have studied particular subjects for entry onto particular courses. Thus, degree specialisation is selected at a relatively young age in Ireland. Given these structural constraints one could argue that female students that have managed to navigate this gendered terrain at post-primary level are a committed cohort and have a strong STEM identity. What their experiences of STEM at third-level are however may be a different story. Therefore, this research aims to investigate their attitudes towards STEM and their experiences as females studying a STEM-related programme at university level. Through investing these experiences, it is intended to inform higher education of ways in which females' educational environment can be improved.

2. Literature Review

2.1 Female STEM undergraduates' association with STEM culture

Research on the main themes that influence females' association with Science Technology, Engineering and Technology groups can generally be categorised as individual attributes, peers and society. These categories are not separate entities they overlap, for example, individual attributes may be influenced by peers and society. The subject of this paper is students' perceived association, therefore we focus on literature regarding non-cognitive factors, mainly sense of belonging and science identity.

The literature pertaining to students' individual attributes suggest that perceived sense of belonging in STEM is a key factor in relating with STEM culture in higher education. Sense of belonging can be defined as 'the extent to which students subjectively perceive that they are valued, accepted, and legitimate members in their academic domain' (Lewis *et al*., 2016, p. 1). Representation within one's STEM discipline impacts sense of belonging for women (Rainey et al, 2018), those from underrepresented groups are less likely to feel they belong. Factors that influence undergraduate students' sense of belonging are social networks (Ovink & Veazey, 2011; Hurtado *et al*., 2008; Hausmann *et al*., 2007), perceived competence (Gummadam *et al*., 2016; Zumbrunn *et al*., 2014) and science identity (Rainey *et al*., 2018). Science identity differs from sense of belonging as it refers to the extent a person identifies as a scientist. The process of developing an identity as a scientist has been explored empirically without any consensus on what the term science identity means (Williams & George-Jackson, 2014). The Carlone and Johnson (2007) science identity model puts forward three related dimensions: competence; performance; and recognition. This study employs the recognition aspect of this model, by inquiring if students view themselves as having similar traits that they perceive scientists possess.

In the literature, there are many references to the 'chilly climate' experienced by female students as they integrate with their peers in male-dominant environments. Walton and colleagues (2015, p. 486) describe this environment as the 'explicit and implicit messages that convey to women that their gender could be a liability in STEM settings'. Studies report that in male-dominant environments, females experience more gender harassment (Dresden, 2018), have less informal interactions with peers (Hosaka, 2014; Amelink & Creamer, 2010) and are faced with the stereotype that they are less capable than their male counterparts (Starr, 2018; Carli *et al*., 2016).

Regarding societal influences, most early studies as well as current work focus on social and cultural capital. Being part of particular communities can afford benefits or social capital (Bourdieu, 1986). When students commence higher education, they already have particular levels of cultural and social capital, but university environments can facilitate students' further obtaining capital (King *et al.*, 2017; Schwartz *et al.*, 2018). Specifically, in relation to female students in STEM, it appears that, although male and female students are in the same social class, their integration into that society and the opportunities available to them may be different (Grunspan *et al.*, 2016; Dumais, 2002). In relation to cultural capital, clear cultural expectations exist in relation to suitable careers for women, which can act as a barrier regardless of the social class of the female student. In terms of social capital, accessing the network of acquaintances in the STEM community is also a challenge given the male domination of the field which it supports. Therefore, looking through the lens of social and cultural capital, it could be argued that both play a significant role in maintaining the gender gap in STEM. As a result, the social integration of this marginal group is critical and much is known about the importance of social integration in higher education (Tinto, 1987;1993).

There has been limited empirical investigation of factors influencing female STEM undergraduates' experiences in the Irish content. The Relevance of Science Education (ROSE) report identified the perceptions of both females and males towards science and showed significant variation in terms of students' motivations, with more males expressing their desire to become scientists in Ireland (Mathews, 2007). Another report published by Accenture (2014) identified the factors that influenced Irish students to choose STEM-related subjects in school. Research involving female STEM students in higher-education remains underdeveloped. In this manuscript, we attempt to fill this literature gap by explicitly investigating female association with STEM culture in higher education.

2.2 Science-related Social Capital

Building on the Bourdieusian understanding of social and cultural capital Archer and colleagues (2015) developed a 'Science Capital Model' to analyse students' possibility of becoming a scientist. This model conceptualises Science Capital as (a) Science-Related Social Capital, (b) Science-Related Behaviours and (c) Science-Related Cultural Capital.

‘Science Capital is not a separate “type” of capital but rather a conceptual device for collating various types of economic, social and cultural capital that specifically relate to science, notably those which have the potential to generate use or exchange value for individuals or groups to support and enhance their attainment, engagement and/or participation in science’ (Archer *et al.,* p. 5).

In this paper we used Science-related Social Capital as a theoretical framework to investigate Female STEM Undergraduates’ perceived alignment with STEM culture as this encompasses Science Identity (individual attributes), supports in STEM course (relationship with peers) and society. As Archer and colleagues (2015) model was originally designed with the intention of exploring the aspirations of children to identify the likelihood of pursuing a career in science, this model was adapted (Table 1). The categories of the model were modified to correspond with students who are already participating in science undergraduate courses. The ‘Knowing Scientists’ component was changed to ‘Perceptions of Women in Science’ as the participants in this study were enrolled in science courses. As part of a science faculty, these participants already know scientists, therefore we wanted to understand their views of women in science. ‘Talking to Others about Science’ was changed to ‘Supports in STEM Course’ as the participants have opportunities to talk about science to their peers, and academic staff. This adaption intended on capturing the perceived level of encouragement participants received from these interactions. Future Science Affinity was removed as all of the students will ultimately obtain a degree in STEM. There was no change to the Science Identity category. By identifying female students’ Perceptions of Women in Science, Parental Science Qualification, Supports in STEM Course, and Science Identity we intend on highlighting areas where females feel they align with STEM culture and areas they do not.

Insert Table 1 about here

Table 1. Adaption of Archer *et al.,* (2015) Science-Related Social Capital

3. Methodology

An exploratory research approach (Singh, 2007) was adopted to gain insights of female students' opinions of women in STEM. This study was framed by two main questions.

1. What are undergraduate female students' perceptions of women in science?
2. Do male and females identify with the characteristics they associate with scientists?

The first phase of this study involved an exploratory survey of all second-year undergraduate female students in all STEM degree programmes (Data set 1, female only). The second phase of this study involved the further exploration of male and females science identity (Date set 2, male and female). The adapted Science-related Social Capital model was the guiding framework used to interpret the data.

All participants were recruited by email. A participant information sheet and a link to the survey were emailed to class list attending a module. The first phase of data collection invited all second-year female undergraduates studying STEM courses at a university. Second-years were selected as it can be assumed that they would be more familiar with the STEM culture at univesity than first-year students. Third-years were not selected as many of the courses partake in work placement, and therefore would not be likely to access their student email. Fourth-year students were not selected as they are usually occupied with coursework, therefore less students would be likely to complete a survey. In total, 78 out of 241 female students completed a survey, representing 23 out of the 28 STEM courses targeted (Data set 1). This sample was statistically representative at 95% confidence level

(10% error).

In data set 2, ‘Science Identity’ was further investigated by asking both male and female undergraduate students to participate. These students were a random sample from STEM courses, therefore the female students who completed the first survey were not the same as this data set. Participants were recruited in a similar manner to the first data set. In total, 157 students participated, 89 females and 68 males (Data set 2). These students were a random sample, and the female students who completed the first survey were not the same as the second survey. This sample was statistically representative at a 95% confidence level (10% error).

3.1 Design of Survey

The survey items relating to Perceptions of Women in Science, Parental Science Qualification, Supports in STEM Course and Science Identity are included in the appendix. The survey items were designed using a combination of existing survey questions (Cell Association Marketing Report, 2010; Krajkovich & Smith, 1982; Erb & Smith, 1984) which focused on the perception of women in STEM careers. The questions largely reflect participants’ perceptions of their involvement in STEM careers, and the enabling and disabling factors of such. The survey was piloted with a cohort of postgraduate STEM students (n=10) and amendments were made to specific questions to improve the clarity of the questions.

3.2 Data Analysis

The open questions were analysed using a content analysis synthesising strategy (Vaismoradi *et al.,* 2013). Themes emerged from the data using an inductive approach. Descriptive coding followed by topic coding was used (Hsieh & Shannon, 2005). From the review of the data, patterns were identified, coding was reviewed, discussed and refined by several researchers. Statistical Package for the Social Sciences (SPSS) was used to collate the data from the closed questions.

Closed questions were coded and frequency counts were performed. The Kruskal-Wallis H test was used to test if there were statistically significant differences between male and female students' opinions about whether they associated a certain characteristic with a scientist or themselves. To use the test, the data satisfied the assumptions that the dependent variable was ordinal (5-point Likert scale), the independent variable consisted of two independent groups (male and female) and the data had independent observations (different participants in each group) (Laerd Statistics, 2017). A non-parametric Levine's test was used to confirm the homogeneity of variance in the data $p > 0.5$ for each trait. In the instances where the variances were equal, medians of the data were compared (Laerd Statistics, 2017). In instances where the data did not have equal variances, mean ranks are reported.

4 Findings

The findings are presented under the categories of 'Perceptions of Women in Science', 'Parental Science Qualification', 'Supports in STEM Course' and 'Science Identity'.

4.1 What are Female Undergraduates Perceptions of Women in Science?

The following section reports on phase one of the study which explored female undergraduate students' perceptions of women in science. To answer this question, students were asked to provide their agreement to a series of statements (1-18 on survey). Questions 1-16 examined how participants viewed females in society (Table 2). It was hypothesised that female students currently enrolled in STEM courses in an Irish university would believe women have equivalent capabilities and equal opportunities in their career. While many of the items indicated that females believe men and women should have equal opportunities in STEM, three questions with fewer than 90% agreement were highlighted. In total, 87% of participants agreed women and men are equally smart at mathematics. In the context that these are female students enrolled in a STEM course, it is very surprising that 13% of females believe there is a difference in male and females' mathematics capabilities. Participant responses to whether gender should be an asset for a career in science were varied; in total, 36% disagreed, 30% selected neutral and 33% agreed. Finally, only 60% agreed that in their ethnic group, men and women have the same educational and employment opportunities in science. This finding highlights that while these women have chosen a career in STEM, they believe they have not had access to the same educational opportunities or will not have access to the same opportunities in the future, which indicates the struggle they face pursuing a career in science.

Table 2 Summary of Responses to Perception of Women in Science Survey

1. 100% agree women can be as good as men in science careers
2. 99% agreed women can make important scientific discoveries
3. 96% disagreed women are not reliable enough to hold top positions in scientific and technical fields
4. 92% disagreed a woman's basic responsibility is raising children
5. 97% disagreed a woman with a science career will have an unhappy life
6. 99% disagreed a woman should put more effort in helping her husband's career than her own career
7. 100% agreed a woman should have the same job opportunities in science careers as a man
8. 100% agreed women should have the same educational opportunities as men
9. 96% disagreed women have less need to study maths and science than men do
10. 87% agreed women and men are equally smart at math
11. 95% disagreed it is better for a woman to study home economics than chemistry
12. 100% disagreed It is wrong for women to seek jobs when there aren't enough jobs for all the men who want them
13. 100% agreed a successful career is as important to a woman as it is to a man
14. 36% Disagree, 30% neutral and 33% agreed that gender should be an asset for a career in science
15. 99% agreed in their ethnic group, men and women should have the same educational and employment opportunities in science
16. 60% agreed in their ethnic group men and women have the same educational and

employment opportunities in science

Question 17 and 18 examined the reasons for unbalanced gender ratio in STEM and leadership positions. The key issues to emerge were social bias, male orientated mind-set, balancing work and family life, lack of roles models and educational environment.

4.2 Social Bias.

In total, 67% of respondents believed that there were fewer women in science and technology due to social bias and a further 51% considered that it was due to the fact that fewer women are hired than men. Similarly, 62% of respondents suggested the reason for lower proportions of women in leadership positions is that priority is given to men. In total, 41% indicated that female supervisors are not desired with one respondent suggesting that '*Women are not taken as seriously as men when in leadership positions'*. These responses imply the female undergraduate students believe women do not receive equal treatment in the STEM workforce.

4.3 Male-oriented Mind-set.

Approximately 64% of respondents considered that there were fewer women than men in the science and technology field due to the male-oriented mind-set. The male orientated mind-set is defined as a set of established attitudes. This was the only response that suggests a difference of traits or qualities possessed by men that account for fewer numbers of women in science and technology fields. A number of respondents (26%) proposed the reason for lower numbers of women in leadership positions was due to the fact that women typically do not seek promotions. These findings imply that females believe the male attitude facilitates success in the STEM workforce.

4.4 Balancing Work and Family Life.

A relatively large proportion of female students (56%) stated that the balancing of work/family life is a significant disabling factor for women deciding to have careers in science and technology. A further 61% stated that balancing work/family life was a factor when considering promotions within their chosen field. In relation to the latter, one respondent elaborated on this by referring to the onus on women to claim responsibility for looking after children in the family home *'Women are often associated with responsibility for children and having a family/maternity leave can discourage employers as when hiring a man it is unlikely they will need such leave'*. These opinions may seem archaic to people who work in STEM careers, however it shows the need to inform third-level female students about the provisions in place in many STEM professions.

4.5 Lack of Role Models.

In total, 48% of participants believed lack of role models accounted for lower numbers of women in the science and technology fields. Approximately 35% of females stated that the reason they believed there was a low proportion of women in leadership positions was due to the lack of role models. These statements highlight the importance participants place on role models in attracting women into STEM careers and also provide the catalyst for women to rise in their STEM profession. It should be noted that if females had access to female role models, it would no doubt assist in elevating stereotypical views of STEM culture.

4.6 Educational Environment.

In total, 39% of respondents considered that there were fewer women than men in the science and technology field due to the educational environment. Students identified a number of disabling factors relating to school experience. For example, one student stated, 'In my own school of over 500 students (all girls) even Agricultural Science is extra-curricular, while two or even three classes are ran [provided] for Leaving Cert Home Economics during class time'. Unfortunately, it is quite typical in Ireland that traditionally male subjects like Physics, Applied Maths and Engineering are not offered in all-girls schools (Murray, 1997).

4.7 Parental Science Qualification

Having a parent or guardian engaged in STEM increases science capital. In total, 74% of the respondents said their parents/guardians were not involved in science-related careers. This suggests that a large proportion of the women who responded were not influenced to choose a career in STEM based on parental experiences in similar careers. The remaining 26% of participants agreed parents did influence their choice to pursue a career in STEM. For example, one student explained that her mother directly encouraged her to choose Engineering when she liked Physics in school.

Support in STEM Courses

The following section sets out the support systems identified by the female STEM students, which influenced their decision to choose a career in STEM.

Support at Third-Level.

In a multiple-mark question, participants were asked to select a person who advises or encourages them. In total 65% stated 'other students', 60% stated 'lecturers' and 39% stated 'laboratory assistants'. It is interesting that peers were a more popular answer than both academic supports of lecturers and laboratory assistants. In relation to 'other students' peer support was identified by a number of respondents with some reporting that they worked collegially to complete assignments. A typical response was *'We work on difficult assignments and help each other out when we don't know what's going on'*. Students put forward their experience of unbalanced gender ratios, for example:

> *It's lonely in the course where everyone else is male, but I enjoy the subject and have lots of friends from other societies and have fun with them, so I can handle it. It would be nice to have support from the rest of the class. Ideally, I would like to make friends with them and support each other.* (Respondent)

Another student commented that it *'Can be intimidating in some classes and labs due to low female / male ratio'*. These comments signify the role of peer-support in creating positive experiences for undergraduate female science students, which can invariably help them to progress in their training. These comments are particularly telling as they link back to the idea of social capital as a function of science capital.

Science Identity

Phase 1: To investigate how female students viewed scientists and their own identity they were asked if they associated a certain characteristic with a scientist and then with themselves. In total 78 female students completed the first iteration of this survey (Figure 1). Female students stated that they were less intelligent, less focused and knew less about the latest discoveries compared to scientists. Female students believed that they were more sociable, had more fun with work colleagues, were more creative and more family-orientated than scientists.

Phase 2: The following section focuses on phase 2 of the study which sought to investigate if male and females had similar views of scientists and their own identity, therefore a second data set was collected with male and female participants. They were asked if they associated a certain characteristic with a scientist and then with themselves. Statistical tests were conducted and only findings where there were statistically significant differences between male and female views were reported.

More females stated that scientists were creative compared to males (Figure 2). A Kruskal-Wallis H test showed that there was a statistically significant difference in male and female views about scientists being creative, $\chi2(2) = 7.75$, $p = 0.005$, with a mean rank score of 85.74 for females, 66.80 for males. It is interesting that more females recognise the need for scientists to be creative than male students. More females than males also stated that they themselves were creative; this was not statistically significant however.

Figure 1. Male and female students' views on their versus scientists' traits (N=157)

The greatest difference between male and females existed in relation to how intelligent they viewed themselves to be, with less females stating they were especially intelligent. A Kruskal-Wallis H test showed that there was a statistically significant difference in male and female views about whether they are especially intelligent , $\chi2(2) = 10.496$, $p = 0.001$, with a mean rank pain score of 62.91 for females, 84.21 for males.

To investigate if lower student grade data was the reason for less females to state they were intelligent, both male and female grade data was analysed. A Shapiro-Wilk test ($p>.05$) and a visual inspection of their histograms and box plots showed student QCA data was normally distributed for male data ($P = 0.119$) and but not for female data ($p= 0.005$). Female student data (3.15) had a higher mean value than male data (3.03). A Wilcoxon Signed-Ranks Test indicated that there was no statistically significant difference between male and female QCA data ($U=2516$, $p<0.05$).

Fewer females than males also stated that they knew a lot about the latest discoveries. A Kruskal-Wallis H test showed that there was a statistically significant difference in male and female views about whether they know about the latest discoveries, $\chi2(2) = 7.562$, p =

0.006, with a mean rank pain score of 64.18 for females, 82.51 for males. In relation to being family orientated, it is interesting to note that a similar percentage of female and male students stated that they were family oriented (no statistical difference), whereas they both stated that scientists were less so. A similar trend is seen with both sexes stating they were more independent, more social, and more cooperative than scientists.

5. Discussion

There are many aspects of the findings that are perhaps expected, given the existing research in this area. For example, the students were aware of social biases in their fields and the masculine culture within STEM. They also were aware of the wider social perceptions of female abilities in relation to science and technology. While some of these findings may seem duplicative of earlier research in the gender space, it is important to note the lack of change in relation to gender stereotypes in STEM. In this context, it could be argued that these students, while not agreeing with these gender stereotypes, are aware of the 'up-hill struggle' that faces females in their profession. However, as the final section of the findings highlight, females appear to have images of professionals in the STEM area (in this case scientists) that does not align well with their science identity. This could suggest that, although initially it would appear that they are aware of the social biases in relation to females in STEM, they too carry some implicit biases that can be self-defeating in terms of their career proficiencies and progression. For example, an analysis of the difference between male and female views indicated that, female students associated less with 'being intelligent' and 'knowing a lot about the latest discoveries', two traits they associated with scientists.

In relation to how females identify with scientists, they are lacking in their beliefs about their competencies. It is evident that both male and females do not associate with many of the traits they believe scientists possess (e.g. focused, not independent, unsociable, uncooperative, work orientated and not family orientated). However, culture roles for particular genders mean that some of these traits would deter more females than male. For example, a female student believing that female scientists are not family-orientated, while in parallel claiming that they themselves are family-orientated, is less likely to consider science as a suitable career for them. While similar views exist within the male group of students, social expectations in relation to women's roles would make it less of an inhibiting factor for males. Viewing this through a social capital lens, it appears that the effects of low science identity may influence a students' belief about their suitability in working as a scientist or even becoming a scientist. This finding is consistent with research conducted by Hazari Sadler, and Sonnert (2013) who report that female undergraduate students had significantly lower self-perceptions towards science.

The lack of exposure to role models in this area might explain some of these perceptions. Female students raised the issue of a lack of role models and the need for mentoring. Without such supports, that often dispel the myths and misconceptions about female STEM professionals, these students may continue to draw from the typical social stereotypes that exist in the wider society and media. This appeared to be evident in the survey where female students rated scientists as being highly intelligent, not sociable or friendly and not very family orientated. Dasgupta (2013) states that,

> "for individuals who are numeric minorities and stereotyped in a field, their implicit attitudes toward science and engineering, identification with these fields, and self-efficacy are heavily influenced by the presence or absence of in-group experts and peers"
>
> (p. 273)

We argue that without appropriate mentoring and supports from role models it is unlikely that these views would be challenged. On the contrary, given the male-dominated environment in which they were entering, there is every possibility that such views would be reinforced rather than challenged.

The study highlights the importance of peers in supporting females in higher education. In instances where females are minorities in STEM courses they can become isolated, as was reported by some students in this study. Etzkowitz, Kemelgor, and Uzzi (2000, p. 16) state 'The experiences of women scientists begin and end with the consequences of social exclusion in an activity that necessitates, perhaps demands, community'. The social capital perspective suggests that the effects of this isolation is not necessarily simply social in nature but may also affect the students' academic progression and career advancement. As Keane (2011) notes, 'forging social connections through relationships with peers is vital for building social capital and for future labour market success' (p. 461). Peer engagement experiences related to coursework were evident in the student responses, for example, the respondents made references to working with other students. This is often overlooked when one considers female participation in STEM. We argue that the isolation experienced by some of the female students on these programmes, not only results in social isolation from the male-dominated peer groups, it also limits opportunities for informal peer learning opportunities that arise on a day-to-day basis in the presence of peers that are enrolled on the same programme of study.

If one's main social base is outside of students that are enrolled in STEM programmes there are few if any opportunities to seek opinions from peers and engage in shared meaning making. Viewed in this light social capital is perhaps more influential in relation to female participation in STEM education than is currently recognised. It suggests that the challenge is greater than encouraging greater collaboration in formal laboratory and project-work and that the complex relationship between the social and academic aspects of students' lives needs to be unpacked more. Social isolation affects female participation in other ways. When one considers the importance of communities of practice in learning (Wenger, 1998), partial engagement in these communities reduces the level of social capital one gains from engagement with them and limits the level of socialisation into the group. Therefore, customs and practices of the peer group may be less understood or at worst not known about by those that have limited engagement with the group. This problem is also reciprocal in nature, as the less the individual is familiar with the norms and practices of a group, the less they will identify with its members.

6. Conclusions

The study reported in the paper provides a basis for future studies. Theresearch highlights the need to support female students enrolled in STEM undergraduate courses so that they feel they belong in STEM. If Irish female undergraduates believe that they will have fewer opportunities in STEM, how can we attract more females to study and pursue a career in STEM? Universities in Ireland have done a great deal in recent decades to improve the participation rates of non-traditional students and those from marginal groups (Skilbeck & Connell, 2000). These measures frequently involved additional supports to assist students in transitioning into university and dealing with the academic demands of the programme. As supports now shift towards targeted groups underrepresented in specific disciplines, such as women in STEM, it is important that initiatives recognise the nuances of these challenges. In particular, staff need to be educated in relation to the experiences of these minority groups.

In addition, the prevailing culture and associated norms and practices of programmes may need to be questioned in terms of whether they limit female students who do not initially identify with the discipline. However, as this study has highlighted, future initiatives should not underestimate the influence of the social aspect of students' lives and how their social worlds interact with their academic study. One may engage and integrate effectively into university life but not necessarily within the community of practice related to their STEM discipline., Future research could explore the informal support accessed by students on STEM programmes from their peers. For example, what support, if any, do students feel they gain from their social/peer groups when studying STEM at third-level and are there gender differences? Questions of this nature may help to highlight the hidden, and often ignored world, of students that can be critical in developing a sense of identity and belonging with their course of study.

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Appendix

Survey Items relating to Perceptions of Women in Science Careers

Please tick the response which best represents your opinion:

	Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Women can be as good as men in science careers					
Women can make important scientific discoveries					
Women are not reliable enough to hold top positions in scientific and technical fields					
A woman’s basic responsibility is raising children					
A woman with a science career will have an unhappy life					
A woman should put in more effort to help her husband’s career than she does with her own career					
A woman should have the same job opportunities in science careers as a man					
Women should have the same educational opportunities as men					
Women have less need to study maths and science than men do					

Women and men are equally smart at math					
It is better for a woman to study home economics than chemistry					
It is wrong for women to seek jobs when there aren't enough jobs for all the men who want them					
A successful career is as important to a woman as it is to a man					
My gender should be an asset for a career in science					
In my ethnic group, men and women should have the same educational and employment opportunities in science					
In my ethnic group, men and women do have the same educational and employment opportunities in science					

Why do you think there are fewer women than men in the science and technology field? (Circle all responses that apply)

Educational Environment
Social Bias
Lack of Role Models
Low Salary
Male-oriented Mind-set
Balancing Work and Family Life
Less hiring of Women than Men
Long Working Hours
Lack of Consideration for Childcare
Other, please specify____

What do you think is (are) the reason(s) for the low proportion of women in leadership positions? (Circle all responses that apply)

Balancing Work and Family Life is difficult
Female Supervisors are not desired
Frequent leaves of absence
Insufficient Female Performance
Lack of Role Models
Females do not seek promotion as much as men
Priority is given to Men
Other, please specify____

Survey Items relating to Science Identity

When I think of a scientist, I think that they:	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Especially intelligent					

Highly focused					
Able to lean to use new equipment quickly					
Competent					
Independent					
Sociable					
Are careful with expensive instruments					
Have fun with colleagues at work					
Cooperative					
Work oriented					
Creative					
Out of touch with popular culture					
Organised					
Money-oriented					
Family oriented					
Know a lot about the latest discoveries					
When I think about myself, I am:					
Especially intelligent					

Highly focused					
Able to lean to use new equipment quickly					
Competent					
Independent					
Sociable					
Careful with expensive instruments					
Have fun with colleagues at work					
Cooperative					
Work oriented					
Creative					
Out of touch with popular culture					
Organised					
Money-oriented					
Family oriented					
Know a lot about the latest discoveries					

Survey Items relating to Supports in Science

Who advises or encourages you?

I. Laboratory Assistant

II. Lecturer

III. Other students

IV. Other person, please specific____

How?

Please describe what support you would like to receive which would help you in your completion of your undergraduate degree?

Please describe what support you would like to receive which would help you in your future career?